PATENT TRADEMARK OFFICE
FEB 19 2006

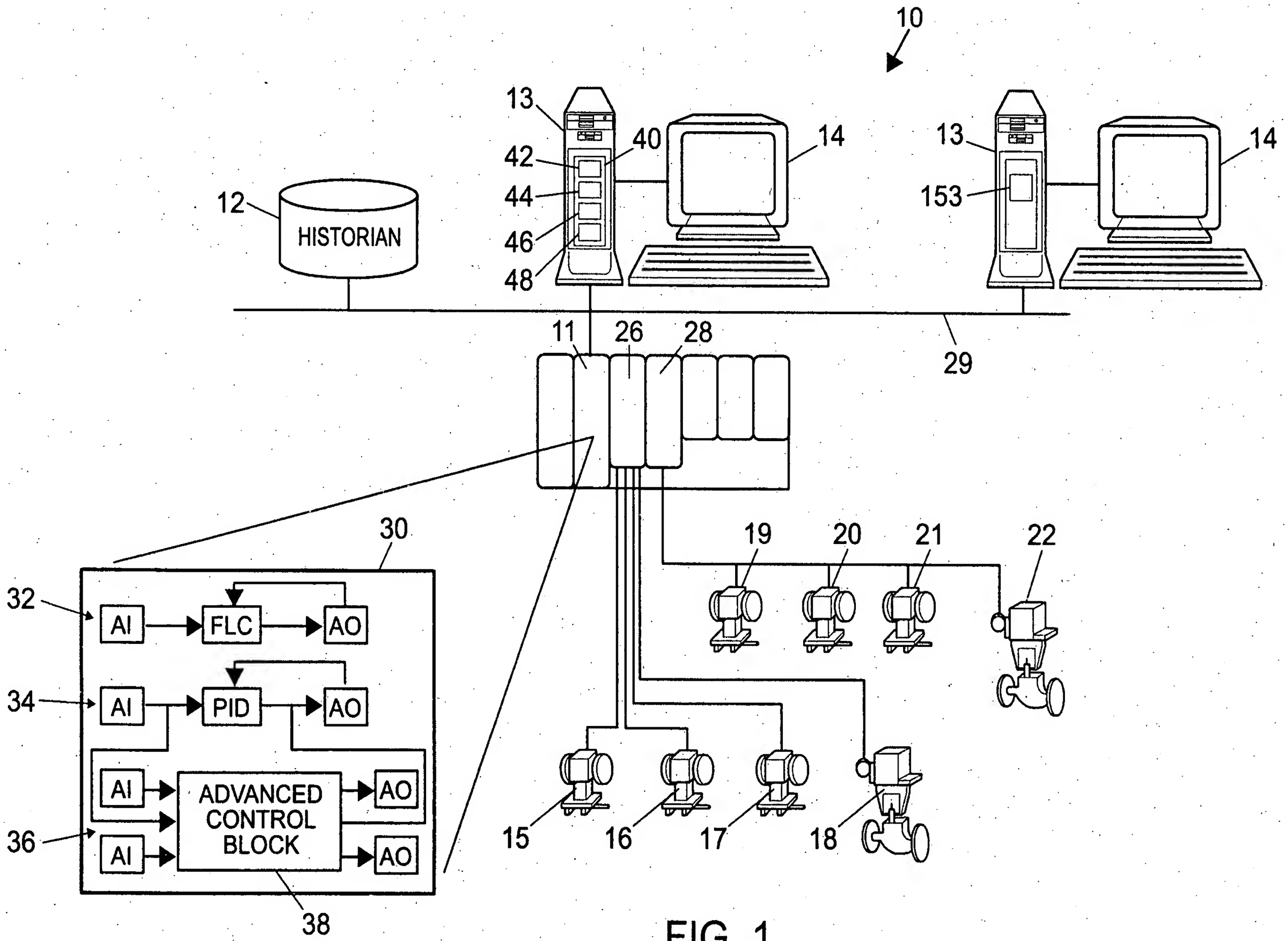


FIG. 1

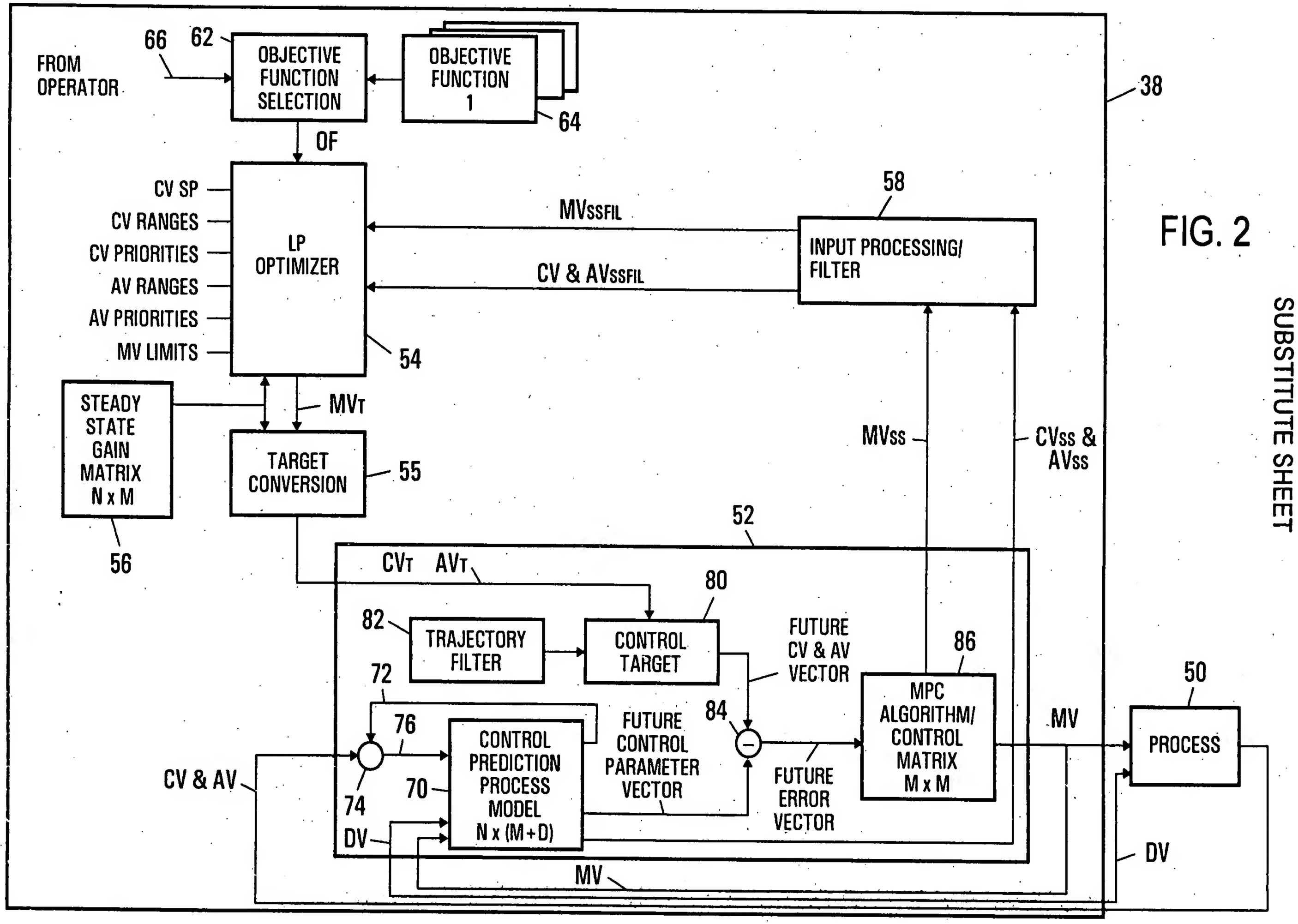


FIG. 2

SUBSTITUTE SHEET

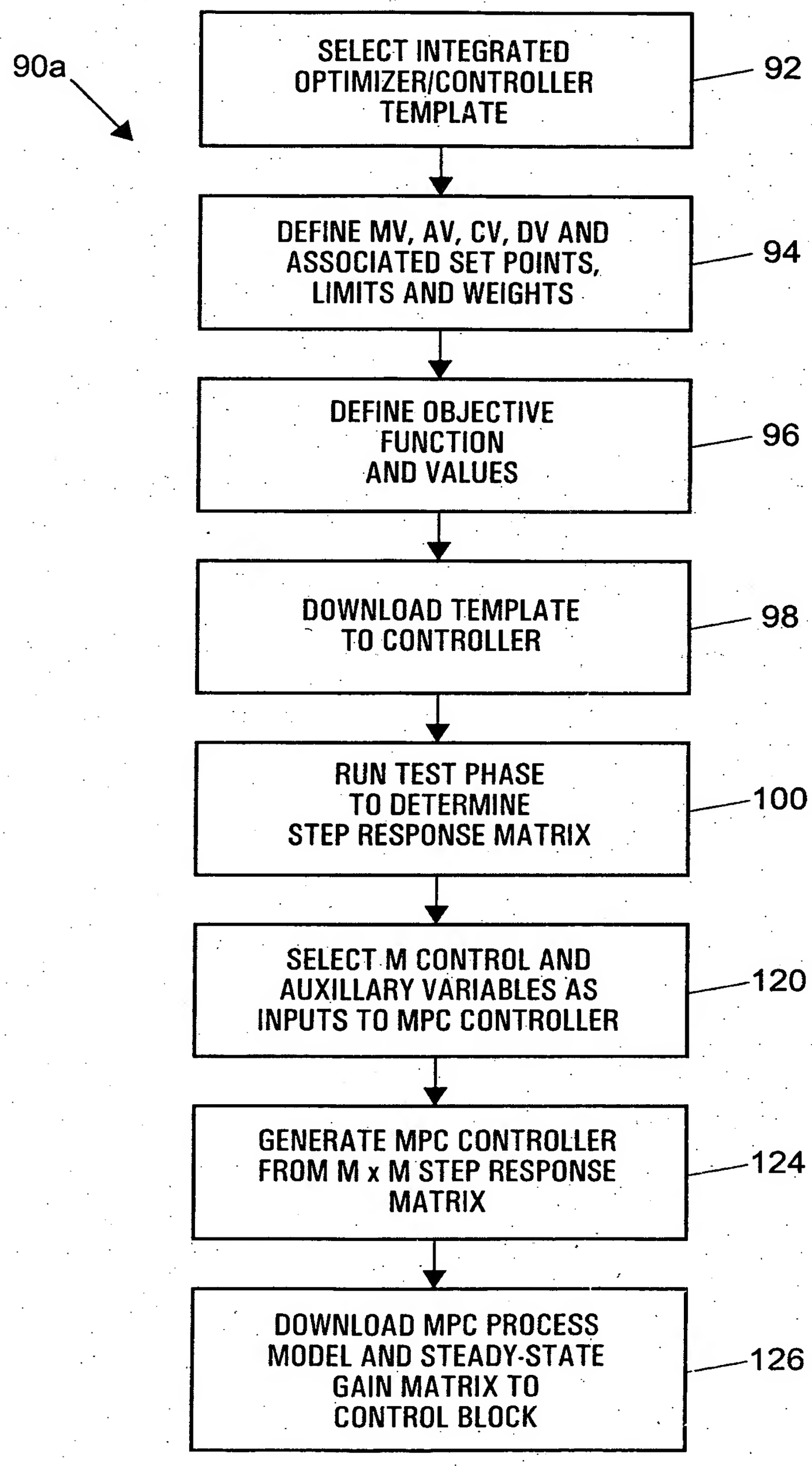

90a
SELECT INTEGRATED OPTIMIZER/CONTROLLER TEMPLATE
92
DEFINE MV, AV, CV, DV AND ASSOCIATED SET POINTS, LIMITS AND WEIGHTS
94
DEFINE OBJECTIVE FUNCTION AND VALUES
96
DOWNLOAD TEMPLATE TO CONTROLLER
98
RUN TEST PHASE TO DETERMINE STEP RESPONSE MATRIX
100
SELECT M CONTROL AND AUXILLARY VARIABLES AS INPUTS TO MPC CONTROLLER
120
GENERATE MPC CONTROLLER FROM M x M STEP RESPONSE MATRIX
124
DOWNLOAD MPC PROCESS MODEL AND STEADY-STATE GAIN MATRIX TO CONTROL BLOCK
126

FIG. 3

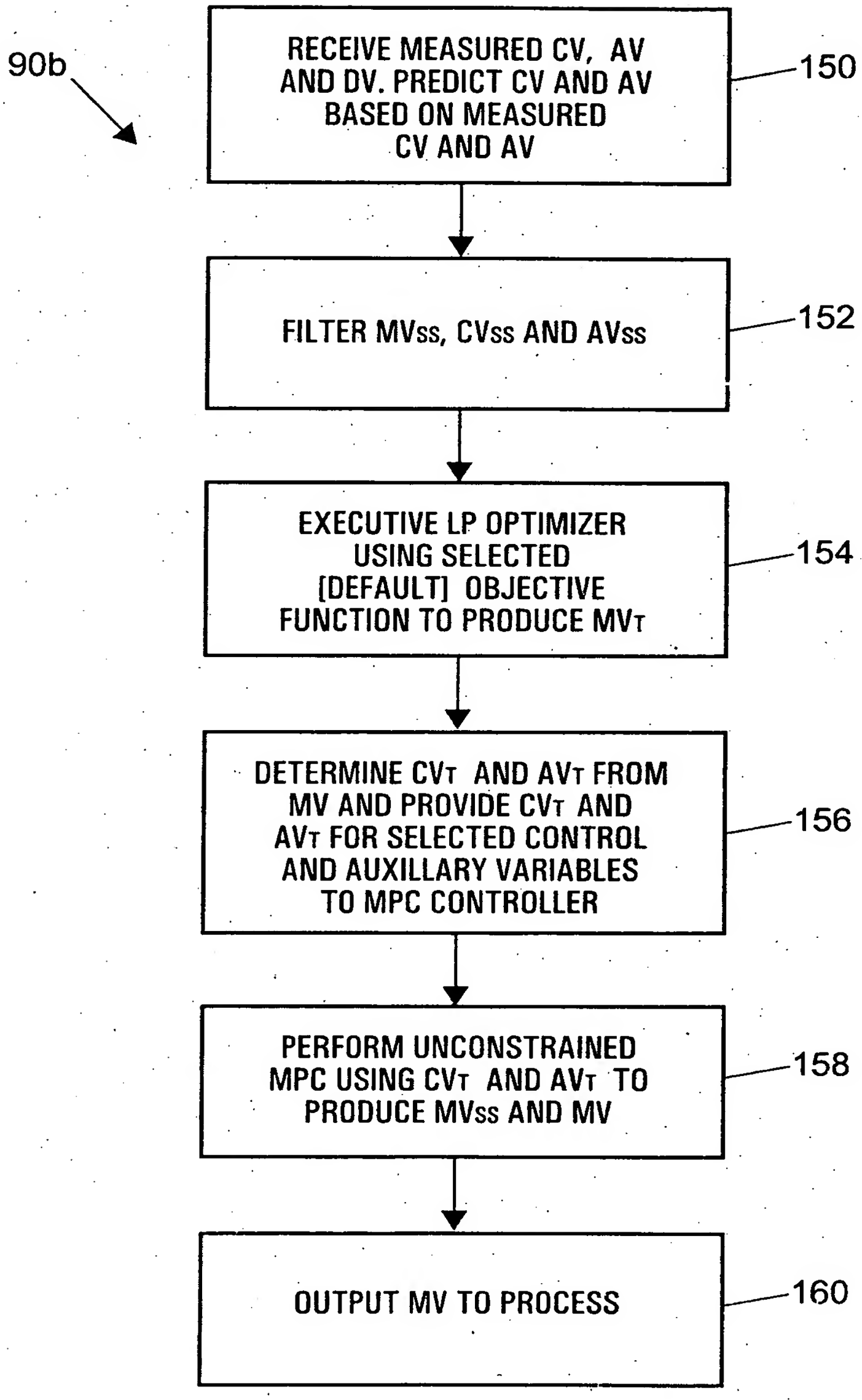

90b
RECEIVE MEASURED CV, AV AND DV. PREDICT CV AND AV BASED ON MEASURED CV AND AV
150
FILTER MVss, CVss AND AVss
152
EXECUTIVE LP OPTIMIZER USING SELECTED [DEFAULT] OBJECTIVE FUNCTION TO PRODUCE MVT
154
DETERMINE CVT AND AVT FROM MV AND PROVIDE CVT AND AVT FOR SELECTED CONTROL AND AUXILLARY VARIABLES TO MPC CONTROLLER
156
PERFORM UNCONSTRAINED MPC USING CVT AND AVT TO PRODUCE MVss AND MV
158
OUTPUT MV TO PROCESS
160

FIG. 4

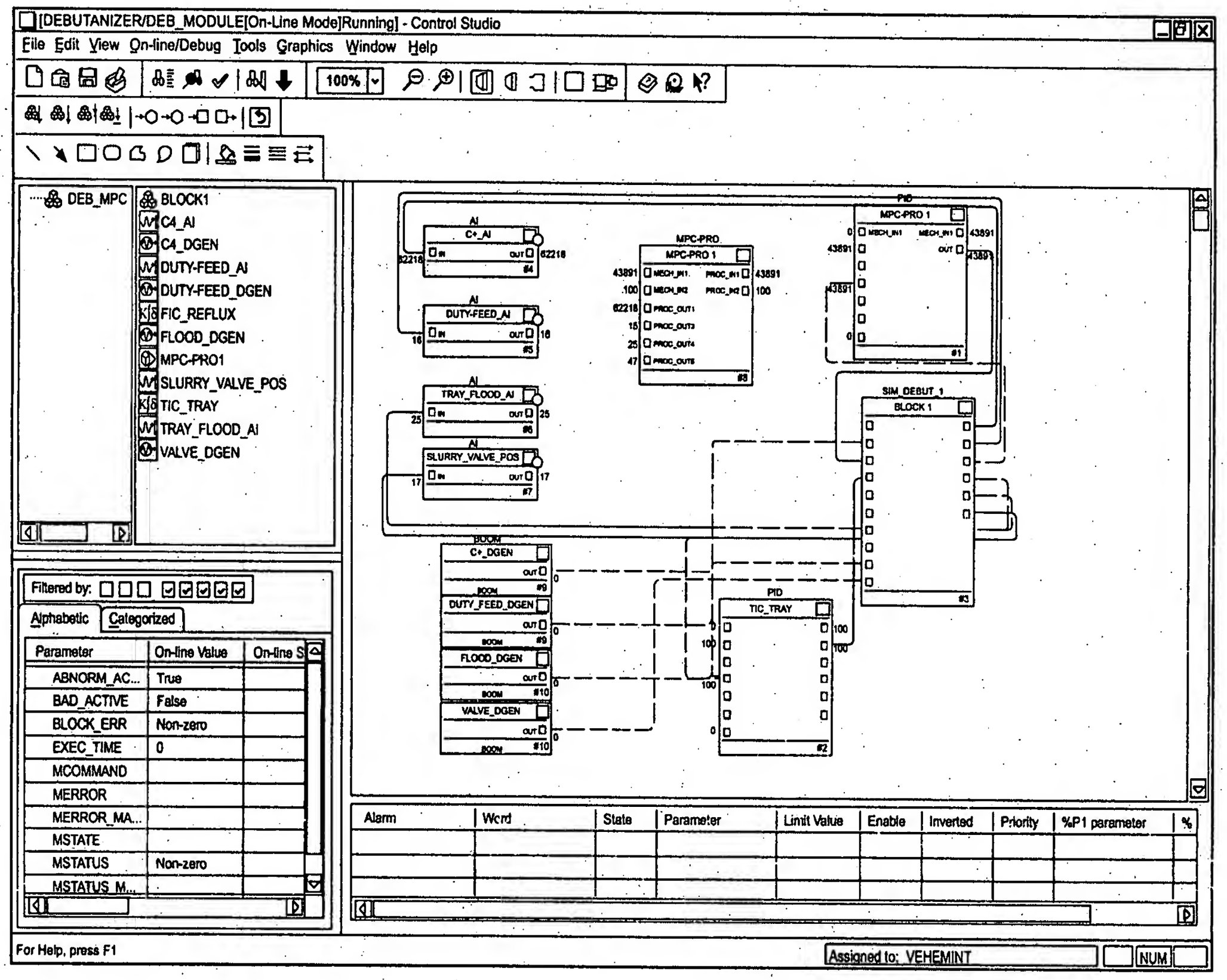

[DEBUTANIZER/DEB_MODULE[On-Line Mode]Running] - Control Studio
File Edit View On-line/Debug Tools Graphics Window Help
100%
DEB_MPC
BLOCK1
C4_AI
C4_DGEN
DUTY-FEED_AI
DUTY-FEED_DGEN
FIC_REFLUX
FLOOD_DGEN
MPC-PRO1
SLURRY_VALVE_POS
TIC_TRAY
TRAY_FLOOD_AI
VALVE_DGEN
Filtered by:
Alphabetic
Categorized
Parameter
On-line Value
ABNORM_AC...
True
BAD_ACTIVE
False
BLOCK_ERR
Non-zero
EXEC_TIME
0
MCOMMAND
MERROR
MERROR_MA...
MSTATE
MSTATUS
Non-zero
MSTATUS_M...
AI
C+_AI
DUTY-FEED_AI
TRAY_FLOOD_AI
SLURRY_VALVE_POS
MPC-PRO
MPC-PRO 1
PID
MPC-PRO 1
SIM_DEBUT_1
BLOCK 1
BOOM
C+_DGEN
DUTY_FEED_DGEN
FLOOD_DGEN
VALVE_DGEN
PID
TIC_TRAY
Alarm
Word
State
Parameter
Limit Value
Enable
Inverted
Priority
%P1 parameter
%
For Help, press F1
Assigned to: VEHEMINT
NUM

FIG. 5

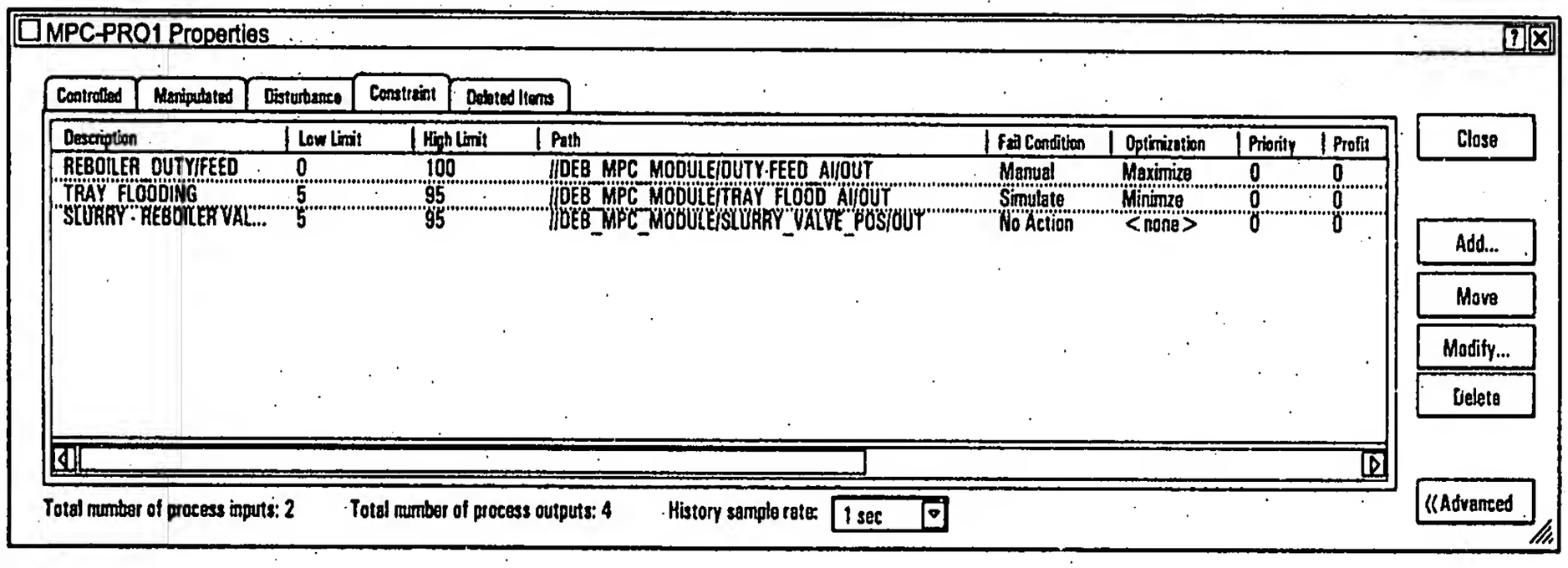

MPC-PRO1 Properties
Controlled
Manipulated
Disturbance
Constraint
Deleted Items
Description
Low Limit
High Limit
Path
Fail Condition
Optimization
Priority
Profit
REBOILER_DUTY/FEED
0
100
//DEB_MPC_MODULE/DUTY-FEED_AI/OUT
Manual
Maximize
0
0
TRAY_FLOODING
5
95
//DEB_MPC_MODULE/TRAY_FLOOD_AI/OUT
Simulate
Minimze
0
0
SLURRY - REBOILER VAL...
5
95
//DEB_MPC_MODULE/SLURRY_VALVE_POS/OUT
No Action
<none>
0
0
Close
Add...
Move
Modify...
Delete
<<Advanced
Total number of process inputs: 2
Total number of process outputs: 4
History sample rate:
1 sec

FIG. 6

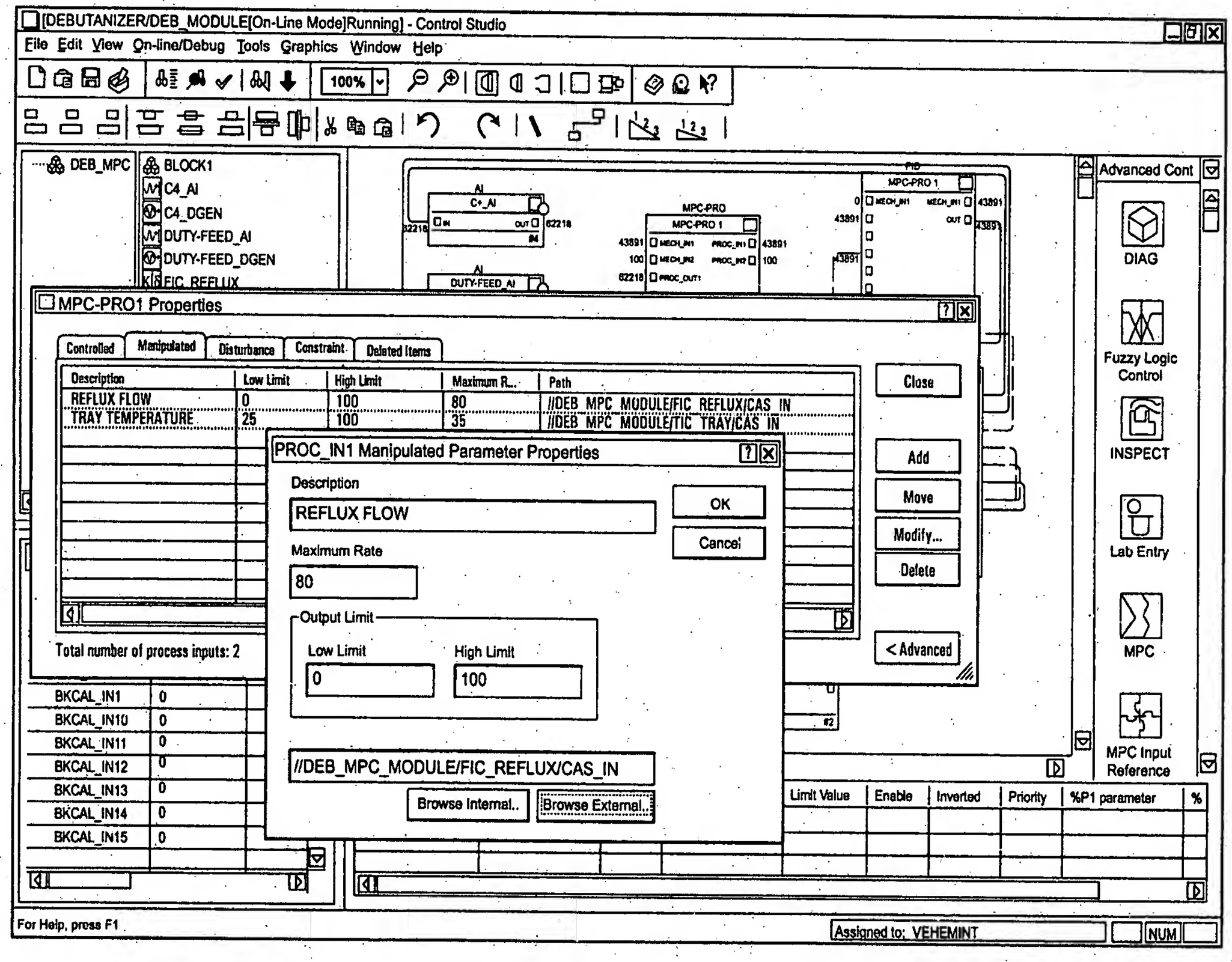

[DEBUTANIZER/DEB_MODULE[On-Line Mode]Running] - Control Studio
File Edit View On-line/Debug Tools Graphics Window Help
100%
DEB_MPC
BLOCK1
C4_AI
C4_DGEN
DUTY-FEED_AI
DUTY-FEED_DGEN
FIC_REFLUX
AI
C+_AI
IN
OUT
62218
#4
AI
DUTY-FEED_AI
MPC-PRO
MPC-PRO 1
MECH_IN1
MECH_IN2
PROC_IN1
PROC_IN2
PROC_OUT1
43591
100
62218
43891
PID
MPC-PRO 1
MECH_IN1
MECH_IN1
OUT
0
43891
43891
43891
MPC-PRO1 Properties
Controlled
Manipulated
Disturbance
Constraint
Deleted Items
Description
Low Limit
High Limit
Maximum R...
Path
REFLUX FLOW
0
100
80
//DEB_MPC_MODULE/FIC_REFLUX/CAS_IN
TRAY TEMPERATURE
25
100
35
//DEB_MPC_MODULE/TIC_TRAY/CAS_IN
Close
Add
Move
Modify...
Delete
< Advanced
Total number of process inputs: 2
PROC_IN1 Manipulated Parameter Properties
Description
REFLUX FLOW
OK
Cancel
Maximum Rate
80
Output Limit
Low Limit
High Limit
0
100
//DEB_MPC_MODULE/FIC_REFLUX/CAS_IN
Browse Internal..
Browse External..
BKCAL_IN1
BKCAL_IN10
BKCAL_IN11
BKCAL_IN12
BKCAL_IN13
BKCAL_IN14
BKCAL_IN15
0
Limit Value
Enable
Inverted
Priority
%P1 parameter
%
Advanced Cont
DIAG
Fuzzy Logic Control
INSPECT
Lab Entry
MPC
MPC Input Reference
For Help, press F1
Assigned to: VEHEMINT
NUM

FIG. 7

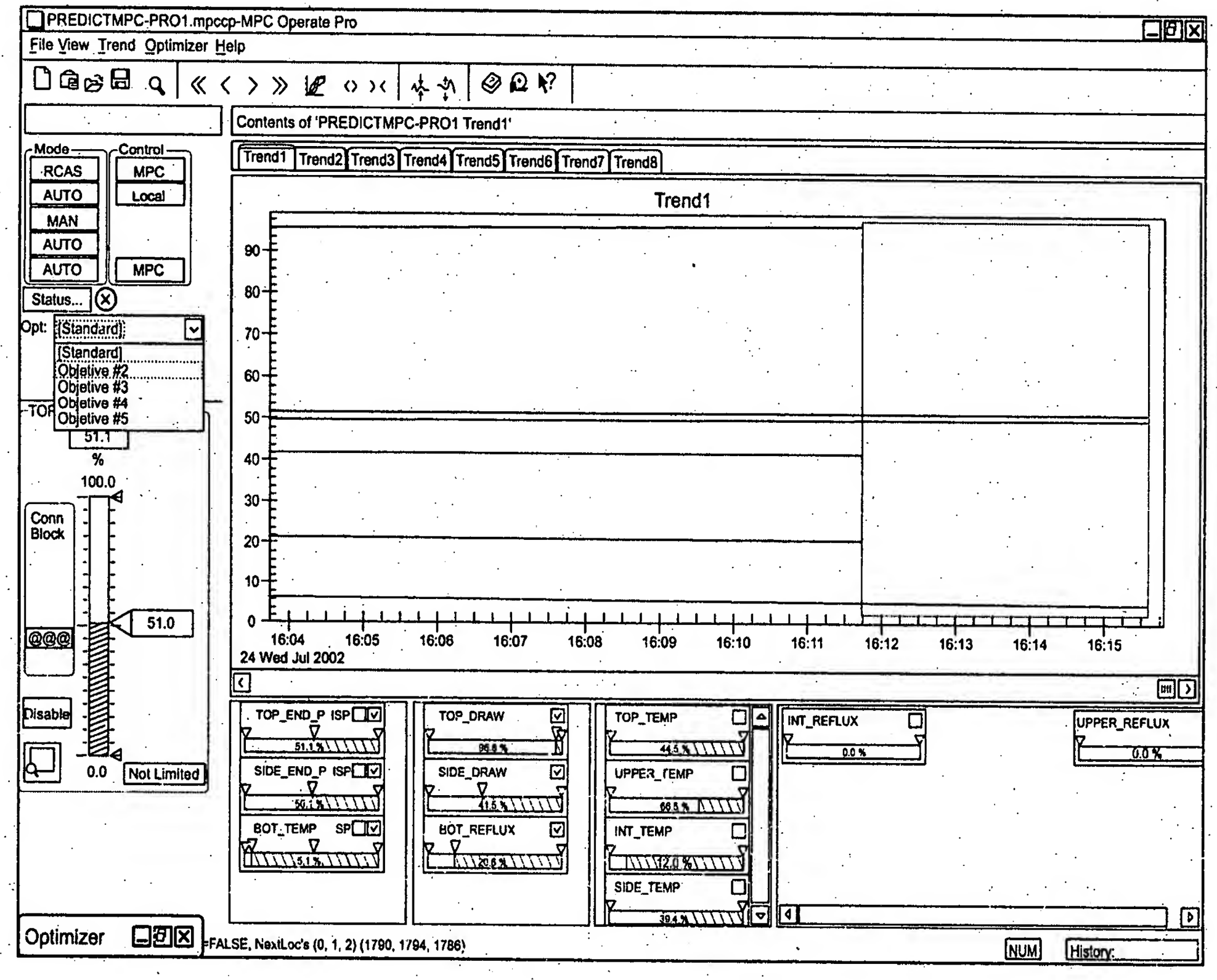

PREDICTMPC-PRO1.mpccp-MPC Operate Pro
File View Trend Optimizer Help
Contents of 'PREDICTMPC-PRO1 Trend1'
Mode
RCAS
AUTO
MAN
AUTO
AUTO
Control
MPC
Local
MPC
Status...
Opt:
[Standard]
[Standard]
Objetive #2
Objetive #3
Objetive #4
Objetive #5
51.1
%
100.0
Conn Block
@@@
51.0
Disable
0.0
Not Limited
Trend1
Trend2
Trend3
Trend4
Trend5
Trend6
Trend7
Trend8
Trend1
90
80
70
60
50
40
30
20
10
0
16:04
16:05
16:06
16:07
16:08
16:09
16:10
16:11
16:12
16:13
16:14
16:15
24 Wed Jul 2002
TOP_END_P ISP
51.1 %
SIDE_END_P ISP
50.1 %
BOT_TEMP SP
5.1 %
TOP_DRAW
96.8 %
SIDE_DRAW
41.5 %
BOT_REFLUX
20.6 %
TOP_TEMP
44.5 %
UPPER_TEMP
66.5 %
INT_TEMP
72.0 %
SIDE_TEMP
39.4 %
INT_REFLUX
0.0 %
UPPER_REFLUX
0.0 %
Optimizer
=FALSE, NextLoc's (0, 1, 2) (1790, 1794, 1786)
NUM
History:

FIG. 8

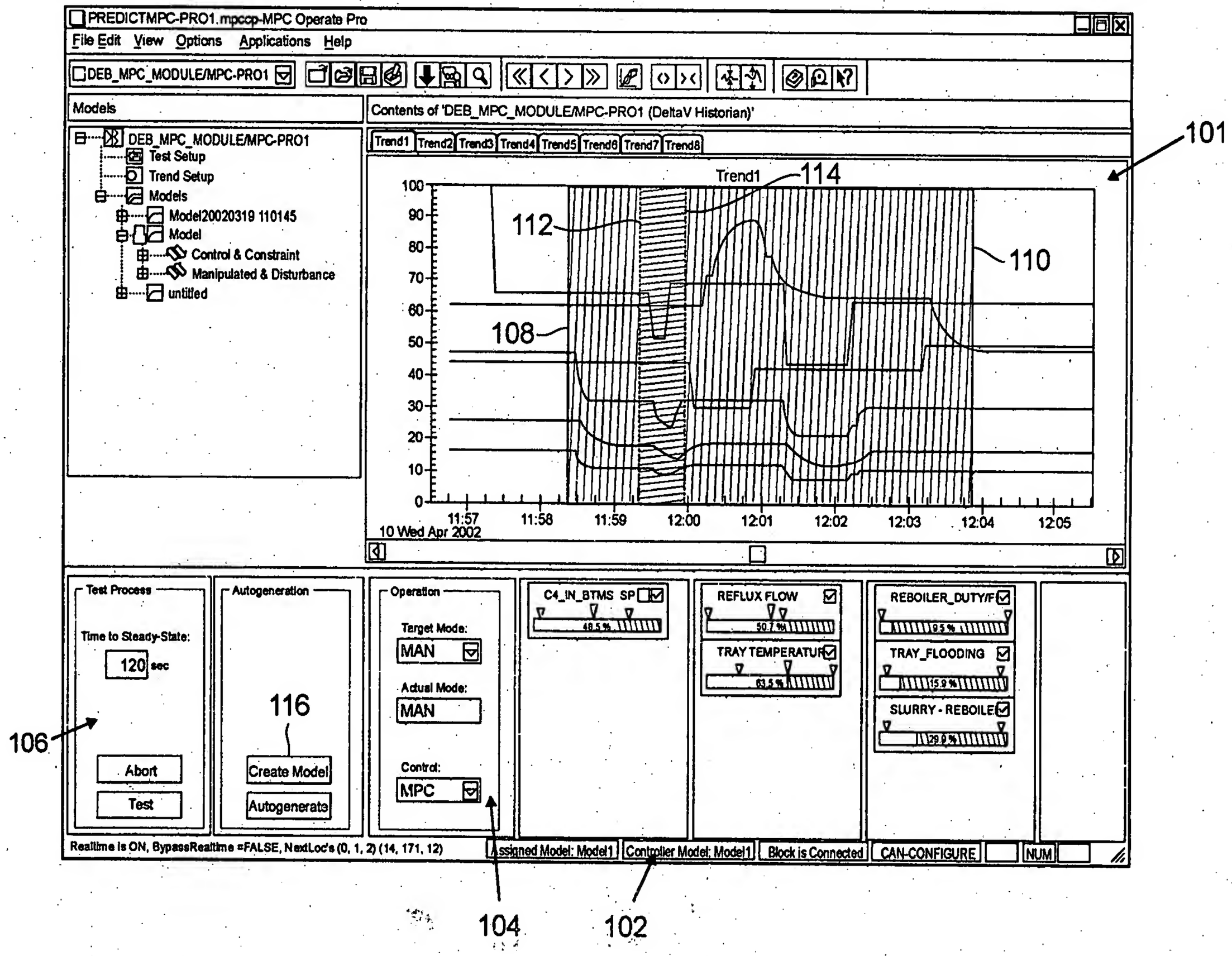

PREDICTMPC-PRO1.mpccp-MPC Operate Pro
File Edit View Options Applications Help
DEB_MPC_MODULE/MPC-PRO1
Models
Contents of 'DEB_MPC_MODULE/MPC-PRO1 (DeltaV Historian)'
DEB_MPC_MODULE/MPC-PRO1
Test Setup
Trend Setup
Models
Model20020319 110145
Model
Control & Constraint
Manipulated & Disturbance
untitled
Trend1 Trend2 Trend3 Trend4 Trend5 Trend6 Trend7 Trend8
Trend1
100
90
80
70
60
50
40
30
20
10
0
11:57
10 Wed Apr 2002
11:58
11:59
12:00
12:01
12:02
12:03
12:04
12:05
101
112
114
110
108
Test Process
Time to Steady-State:
120 sec
Abort
Test
Autogeneration
116
Create Model
Autogenerate
Operation
Target Mode:
MAN
Actual Mode:
MAN
Control:
MPC
C4_IN_BTMS SP
48.5 %
REFLUX FLOW
50.7 %
TRAY TEMPERATUR
63.5 %
REBOILER_DUTY/F
9.5 %
TRAY_FLOODING
15.9 %
SLURRY - REBOILE
29.9 %
106
Realtime is ON, BypassRealtime =FALSE, NextLoc's (0, 1, 2) (14, 171, 12)
Assigned Model: Model1
Controller Model: Model1
Block is Connected
CAN-CONFIGURE
NUM
104
102

FIG. 9

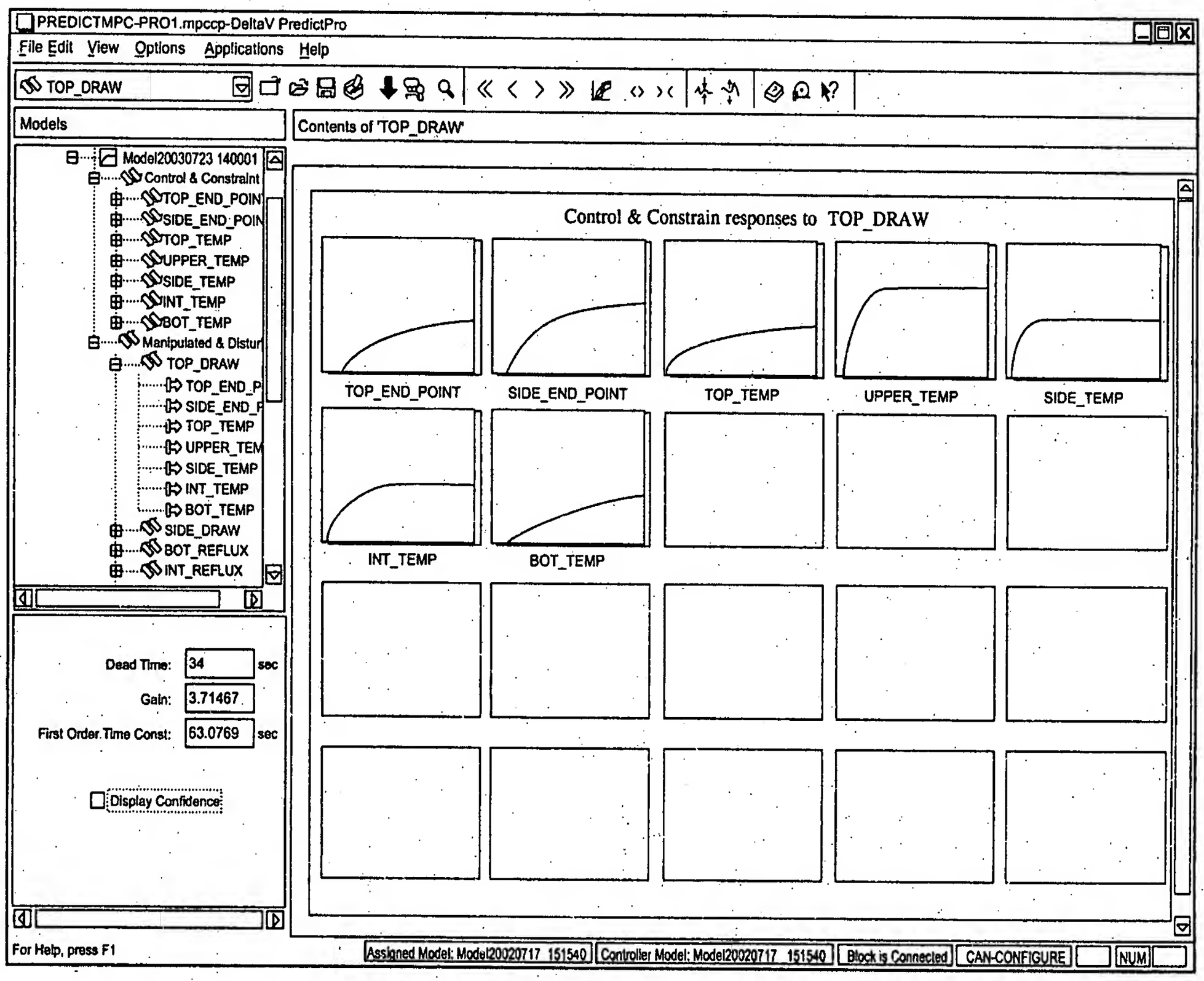

PREDICTMPC-PRO1.mpccp-DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of 'TOP_DRAW'
Model20030723 140001
Control & Constraint
TOP_END_POIN
SIDE_END_POIN
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Distur
TOP_DRAW
TOP_END_P
SIDE_END_P
TOP_TEMP
UPPER_TEM
SIDE_TEMP
INT_TEMP
BOT_TEMP
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
Control & Constrain responses to TOP_DRAW
TOP_END_POINT
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Dead Time: 34 sec
Gain: 3.71467
First Order Time Const: 63.0769 sec
Display Confidence
For Help, press F1
Assigned Model: Model20020717_151540
Controller Model: Model20020717_151540
Block is Connected
CAN-CONFIGURE
NUM

FIG. 10

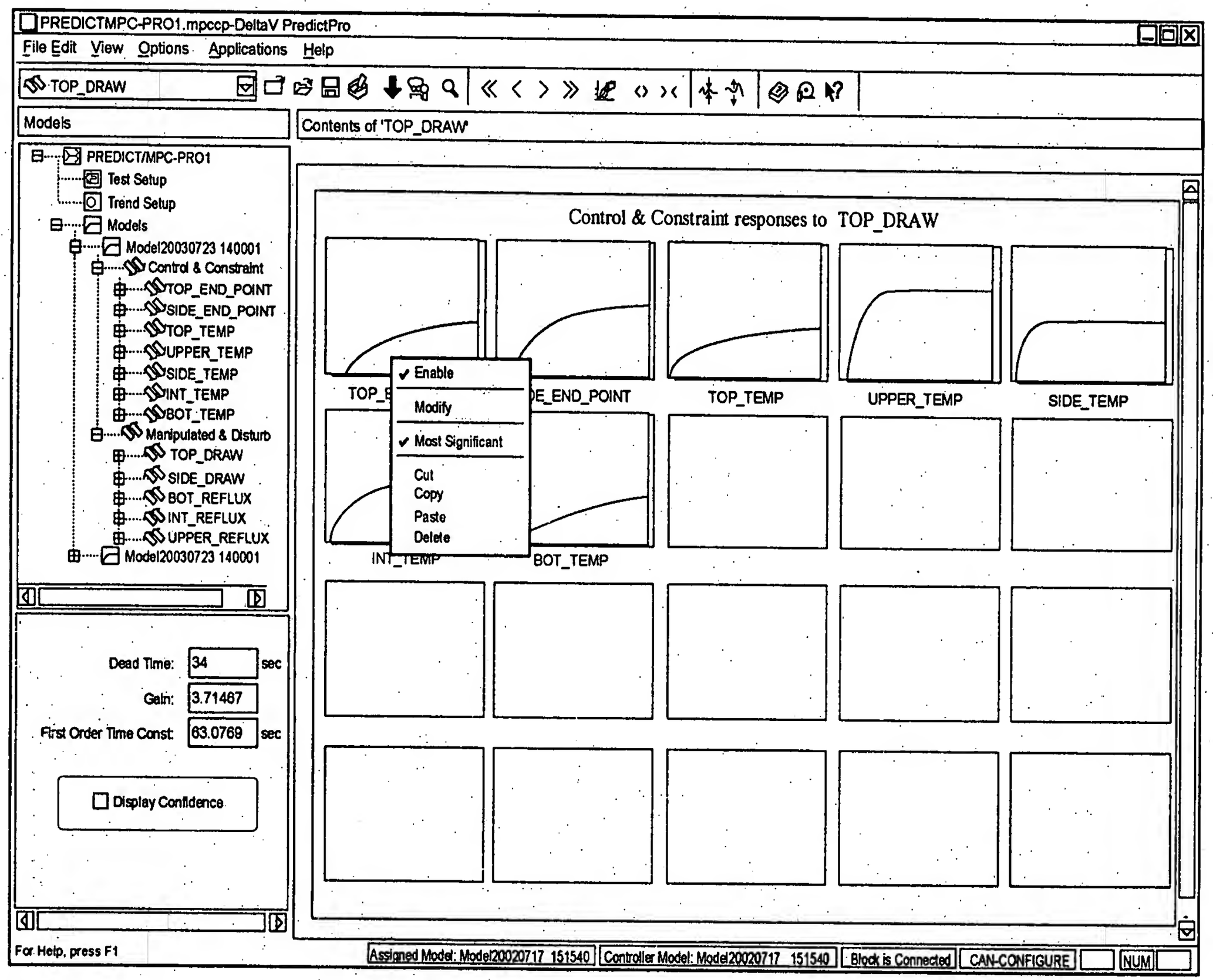

PREDICTMPC-PRO1.mpccp-DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of 'TOP_DRAW'
PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20030723 140001
Control & Constraint
TOP_END_POINT
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Disturb
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFLUX
Model20030723 140001
Control & Constraint responses to TOP_DRAW
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Enable
Modify
Most Significant
Cut
Copy
Paste
Delete
Dead Time: 34 sec
Gain: 3.71467
First Order Time Const: 63.0769 sec
Display Confidence
For Help, press F1
Assigned Model: Model20020717_151540
Controller Model: Model20020717_151540
Block is Connected
CAN-CONFIGURE
NUM

FIG. 11

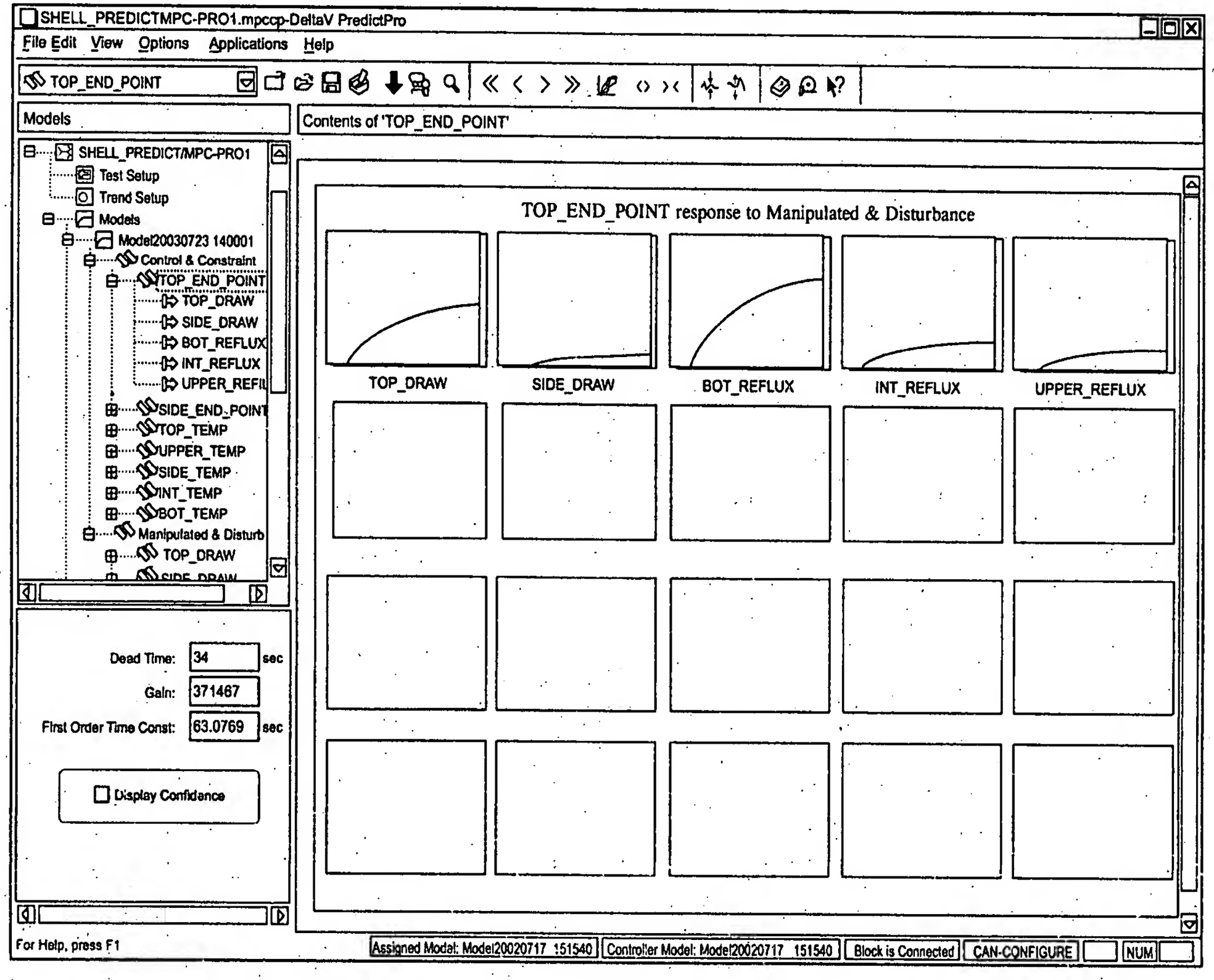

SHELL_PREDICTMPC-PRO1.mpccp-DeltaV PredictPro
File Edit View Options Applications Help
TOP_END_POINT
Models
Contents of 'TOP_END_POINT'
SHELL_PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20030723 140001
Control & Constraint
TOP_END_POINT
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFL
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Disturb
TOP_DRAW
Dead Time: 34 sec
Gain: 371467
First Order Time Const: 63.0769 sec
Display Confidance
TOP_END_POINT response to Manipulated & Disturbance
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFLUX
For Help, press F1
Assigned Modal: Model20020717_151540
Controller Model: Model20020717_151540
Block is Connected
CAN-CONFIGURE
NUM

FIG. 12

FIG. 13

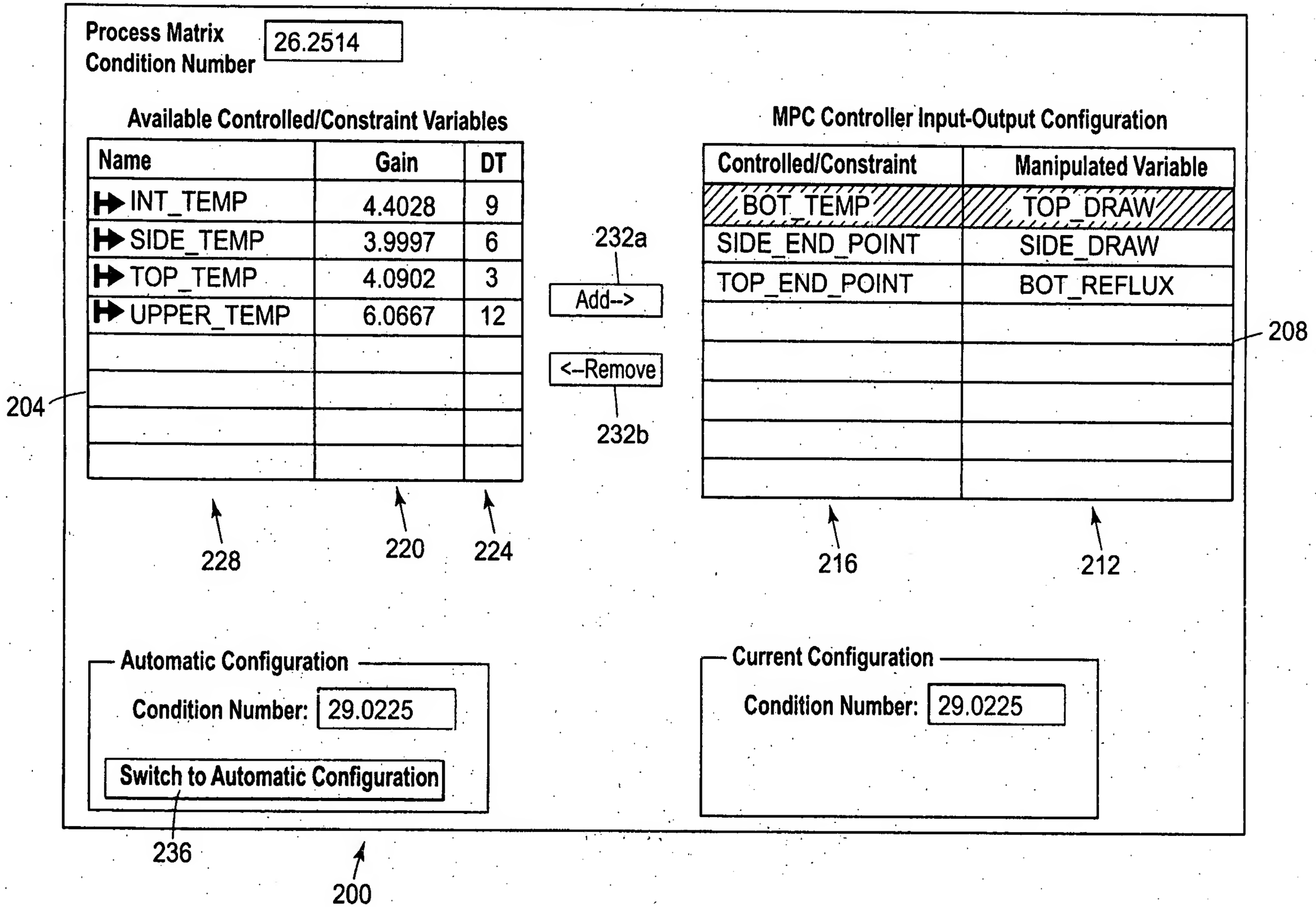
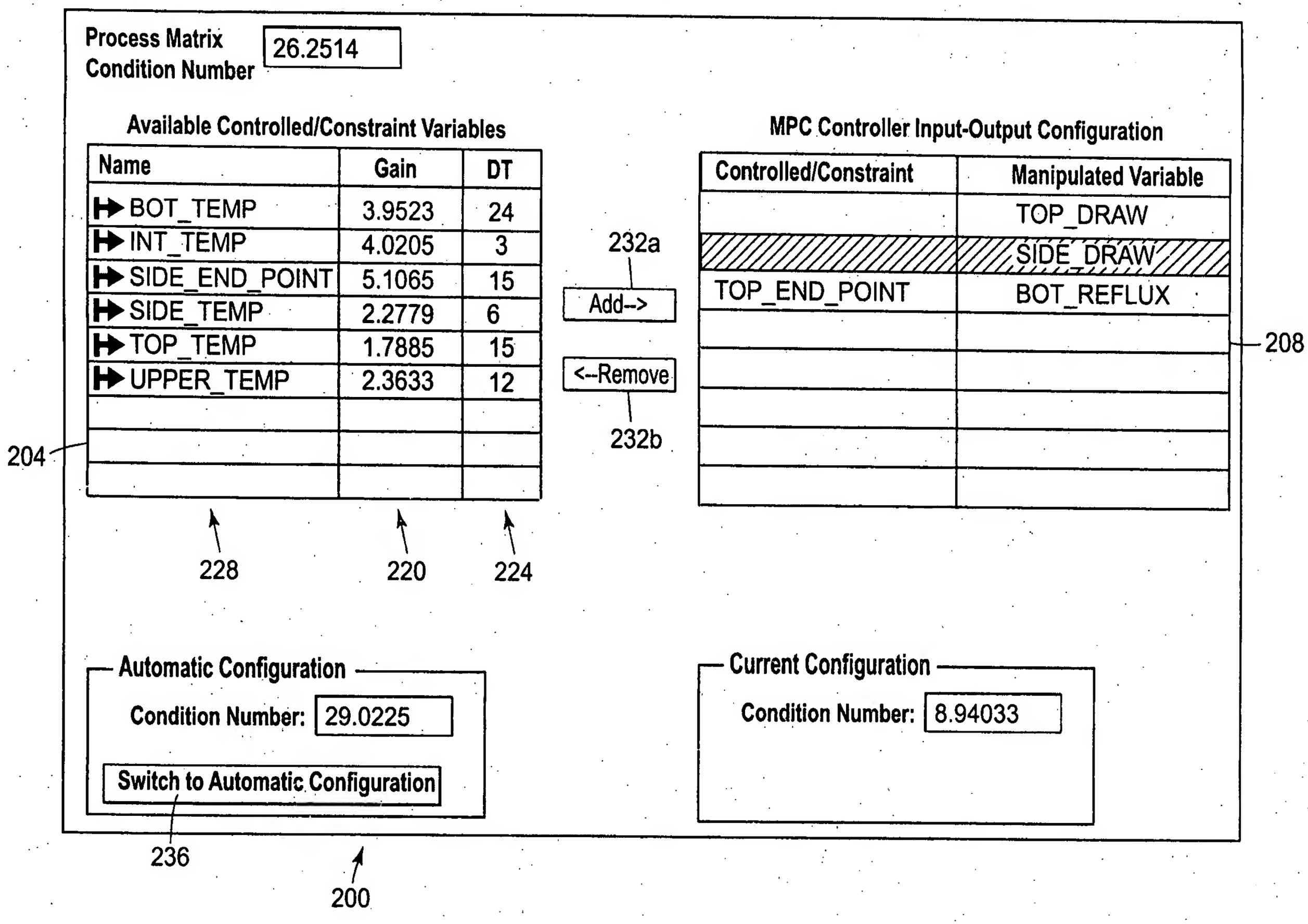

Process Matrix Condition Number
26.2514
Available Controlled/Constraint Variables
Name
Gain
DT
INT_TEMP
4.4028
9
SIDE_TEMP
3.9997
6
TOP_TEMP
4.0902
3
UPPER_TEMP
6.0667
12
204
228
220
224
232a
Add-->
<--Remove
232b
MPC Controller Input-Output Configuration
Controlled/Constraint
Manipulated Variable
BOT_TEMP
TOP_DRAW
SIDE_END_POINT
SIDE_DRAW
TOP_END_POINT
BOT_REFLUX
208
216
212
Automatic Configuration
Condition Number:
29.0225
Switch to Automatic Configuration
236
Current Configuration
Condition Number:
29.0225
200

FIG. 14


Process Matrix Condition Number
26.2514
Available Controlled/Constraint Variables
Name
Gain
DT
BOT_TEMP
3.9523
24
INT_TEMP
4.0205
3
SIDE_END_POINT
5.1065
15
SIDE_TEMP
2.2779
6
TOP_TEMP
1.7885
15
UPPER_TEMP
2.3633
12
204
228
220
224
232a
Add-->
<--Remove
232b
MPC Controller Input-Output Configuration
Controlled/Constraint
Manipulated Variable
TOP_DRAW
SIDE_DRAW
TOP_END_POINT
BOT_REFLUX
208
Automatic Configuration
Condition Number:
29.0225
Switch to Automatic Configuration
236
Current Configuration
Condition Number:
8.94033
200

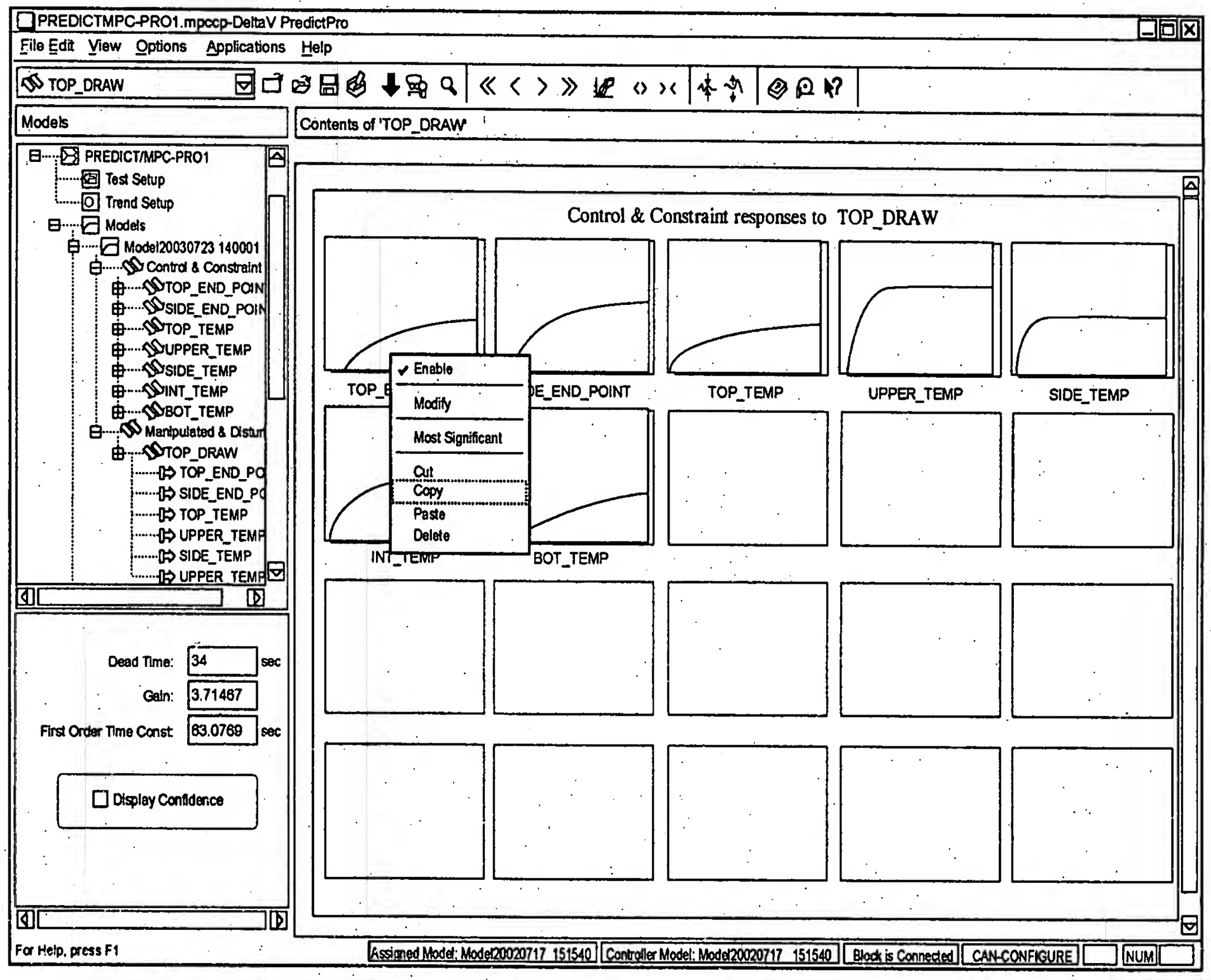

PREDICTMPC-PRO1.mpccp-DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of 'TOP_DRAW'
PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20030723 140001
Control & Constraint
TOP_END_POIN
SIDE_END_POIN
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Distur
TOP_DRAW
TOP_END_PO
SIDE_END_PO
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
UPPER_TEMP
Control & Constraint responses to TOP_DRAW
TOP_E
DE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Enable
Modify
Most Significant
Cut
Copy
Paste
Delete
Dead Time: 34 sec
Gain: 3.71467
First Order Time Const: 63.0769 sec
Display Confidence
For Help, press F1
Assigned Model: Model20020717_151540
Controller Model: Model20020717_151540
Block is Connected
CAN-CONFIGURE
NUM

FIG. 15

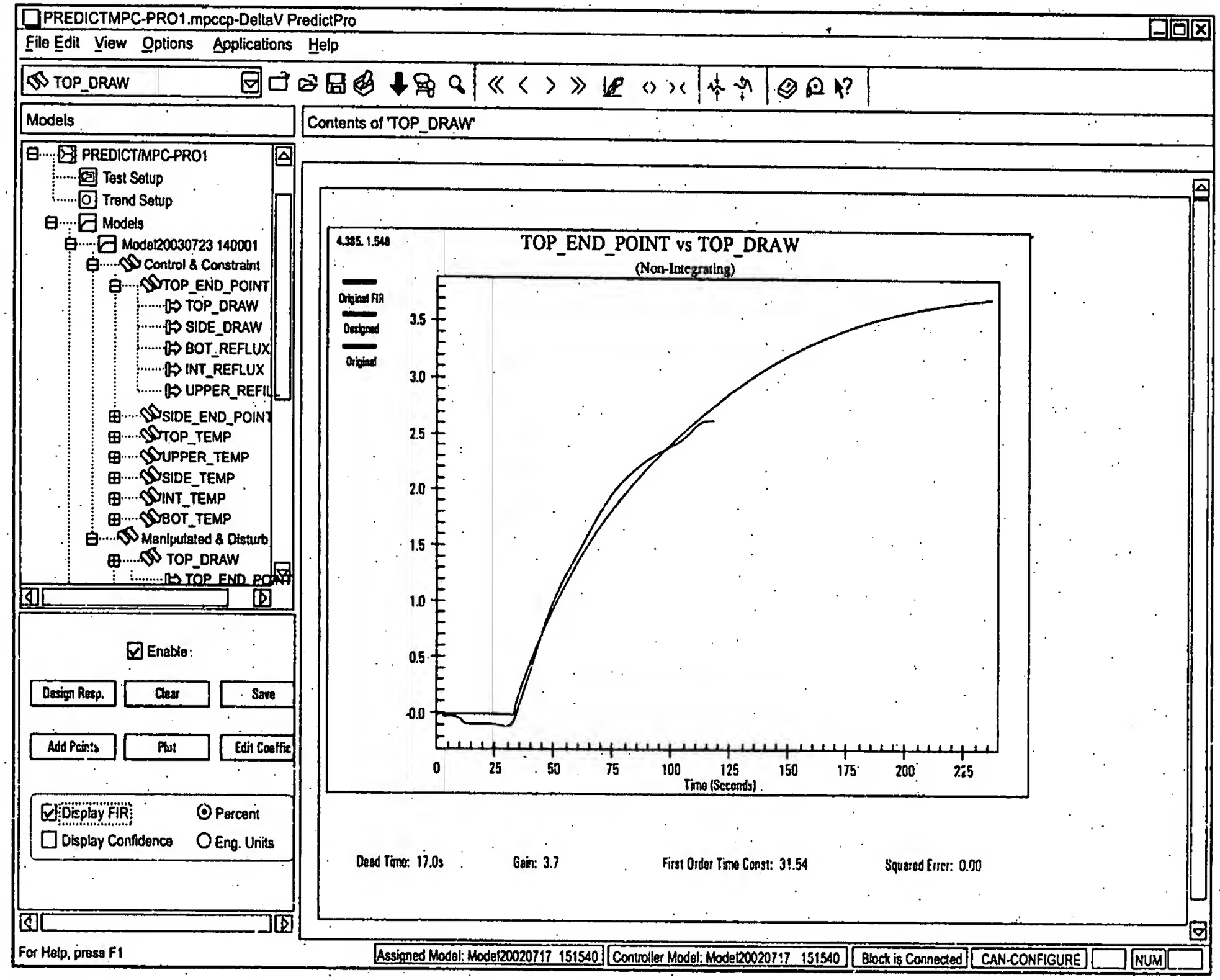

PREDICTMPC-PRO1.mpccp-DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of 'TOP_DRAW'
PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20030723 140001
Control & Constraint
TOP_END_POINT
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFL
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Disturb
TOP_DRAW
TOP_END_POINT
Enable
Design Resp.
Clear
Save
Add Points
Plot
Edit Coeffic
Display FIR
Percent
Display Confidence
Eng. Units
4.385, 1.548
TOP_END_POINT vs TOP_DRAW
(Non-Integrating)
Original FIR
Designed
Original
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.0
0
25
50
75
100
125
150
175
200
225
Time (Seconds)
Dead Time: 17.0s
Gain: 3.7
First Order Time Const: 31.54
Squared Error: 0.00
For Help, press F1
Assigned Model: Model20020717 151540
Controller Model: Model20020717 151540
Block is Connected
CAN-CONFIGURE
NUM

FIG. 16

Optimizer

Inputs (MV)

Descriptor	Current Value	Target Value	Units	Unit Value	Min/Max
TOP_DRAW	96.85	100.00	%	0.10	None
SIDE_DRAW	41.50	41.08	%	0.10	None
BOT_REFLUX	20.48	18.38	%	0.10	Min

Outputs (CV, AV)

Descriptor	Current Value	SP	Target SP	TSP Active	Prediction	Units	Unit Valu
TOP_END_POINT	51.10	51.00	51.00	Yes	51.10	%	1.00
SIDE_END_POINT	50.07	50.00	50.00	Yes	50.10	%	1.00
TOP_TEMP	44.40		45.30	Not in ctrl	44.31	%	1.00
UPPER_TEMP	66.58		70.84	Not in ctrl	66.79	%	1.00
BOT_TEMP	4.85	50.00	5.03	Yes	4.89	%	1.00
INT_TEMP	11.84		10.90	Not in ctrl	11.94	%	1.00
SIDE_TEMP	39.32		40.94	Not in ctrl	39.70	%	1.00

Target SP de/activation -rightclick on Yes/No
Unit Value Change -rightclick on Value
Minimize/Maximize/None change -rightclick on Min/Max/None
Priority -rightclick on value

Close

FIG. 17

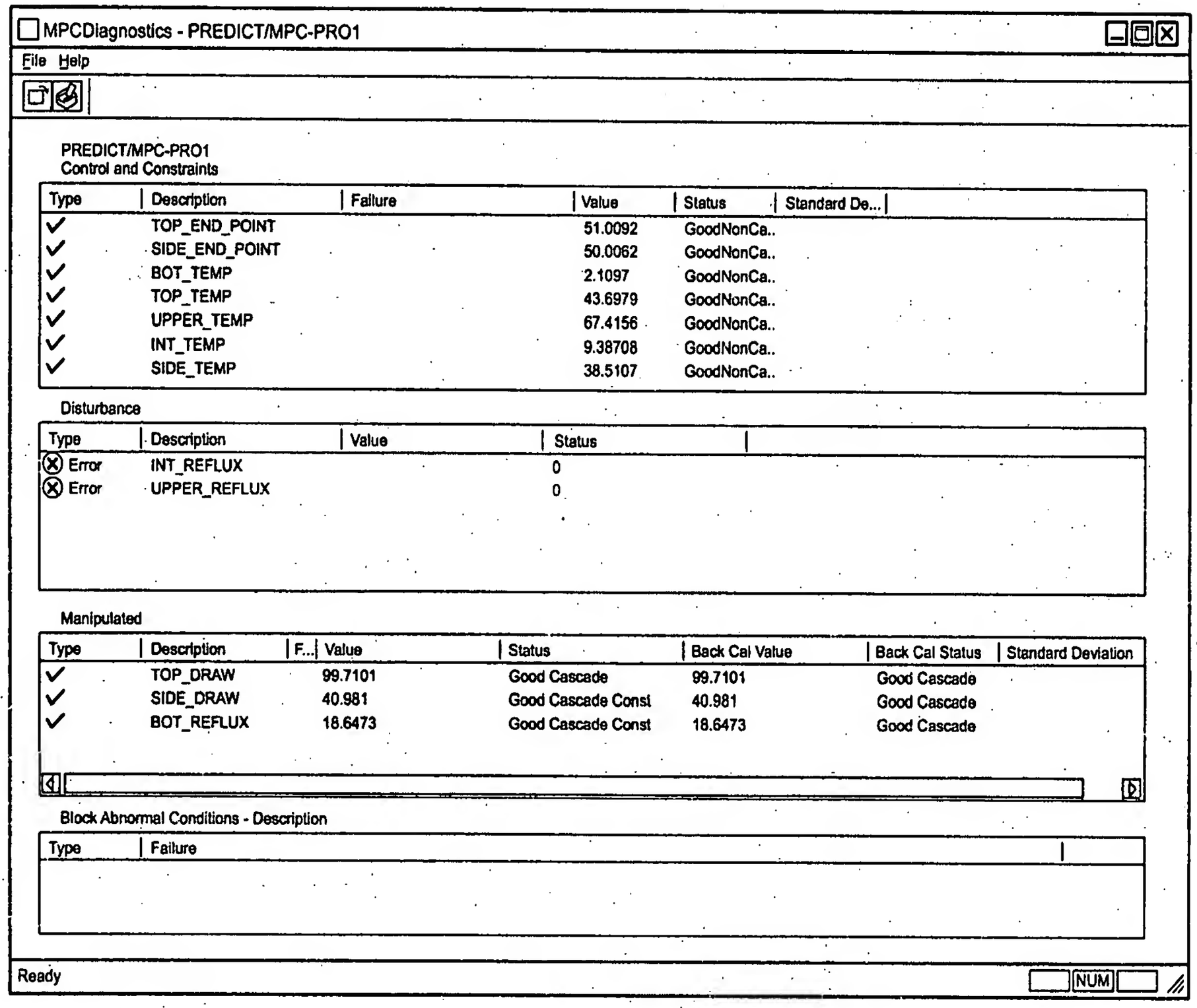

MPCDiagnostics - PREDICT/MPC-PRO1
File Help
PREDICT/MPC-PRO1
Control and Constraints
Type | Description | Failure | Value | Status | Standard De...
TOP_END_POINT 51.0092 GoodNonCa..
SIDE_END_POINT 50.0062 GoodNonCa..
BOT_TEMP 2.1097 GoodNonCa..
TOP_TEMP 43.6979 GoodNonCa..
UPPER_TEMP 67.4156 GoodNonCa..
INT_TEMP 9.38708 GoodNonCa..
SIDE_TEMP 38.5107 GoodNonCa..
Disturbance
Type | Description | Value | Status
Error INT_REFLUX 0
Error UPPER_REFLUX 0
Manipulated
Type | Description | F... | Value | Status | Back Cal Value | Back Cal Status | Standard Deviation
TOP_DRAW 99.7101 Good Cascade 99.7101 Good Cascade
SIDE_DRAW 40.981 Good Cascade Const 40.981 Good Cascade
BOT_REFLUX 18.6473 Good Cascade Const 18.6473 Good Cascade
Block Abnormal Conditions - Description
Type | Failure
Ready
NUM

FIG. 18